Relaxation in X-Space Magnetic Particle Imaging.

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Authors: L Croft, P Goodwill, S Conolly

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Public Summary:
Magnetic particle imaging (MPI) is a new imaging modality that non-invasively images the spatial distribution of superparamagnetic iron oxide nanoparticles (SPIOs). MPI has demonstrated high contrast and zero attenuation with depth, and MPI promises superior safety compared to current angiography methods, X-ray, CT, and MRI angiography. Nanoparticle relaxation can delay the SPIO magnetization, and in this work we investigate the open problem of the role relaxation plays in MPI scanning and its effect on the image. We begin by amending the x-space theory of MPI to include nanoparticle relaxation effects. We then validate the amended theory with experiments from a Berkeley x-space relaxometer and a Berkeley x-space projection MPI scanner. Our theory and experimental data indicate that relaxation reduces SNR and asymmetrically blurs the image in the scanning direction. While relaxation effects can have deleterious effects on the MPI scan, we show theoretically and experimentally that x-space reconstruction remains robust in the presence of relaxation. Furthermore, the role of relaxation in x-space theory provides guidance as we develop methods to minimize relaxation-induced blurring. This will be an important future area of research for the MPI community.

Scientific Abstract:
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